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ON CRETACEOUS PITYOXYLA.[1]

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(WITH PLATES I AND II)

IN a recent publication Dr. ARTHUR HOLLICK[2] has described the discovery of amber in the Raritan formation of the Middle Cretaceous, at Kreischerville, Staten Island. The amber in question occurs in largest quantity "in a stratum or bed, characterized by layers and closely packed masses of vegetable débris, consisting of leaves, twigs, and fragments of lignite and charred wood." Lignite occurring in association with amber at Cape Sable, Magothy River, Anne Arundel County, Maryland, collected by Professor A. BIBBINS of the Woman's College, Baltimore, and of somewhat similar geological horizon, has recently been determined by Dr. F. H. KNOWLTON[3] of the United States Geological Survey as a new species of Cupressinoxylon. It appeared desirable to one of us that the lignites associated with the Kreischerville deposits of amber should be subjected to microscopic examination, in view of the possibility that the succiniferous ones might also turn out to belong to an extinct species of Sequoia (Cupressinoxylon). On communicating with Dr. HOLLICK in regard to this possibility, he very kindly consented to a combined visit to the beds at Kreischerville, for the purpose of securing authentic specimens of the succiniferous and other lignites. On April 18, 1905, we examined together the various

[1] Contributions from the Phanerogamic Laboratories of Harvard University, No. 5.

[2] Amer. Nat. **39**:137–145. 1905. Contributions from the New York Botanical Garden, No. 64.

[3] American amber-producing tree. Science N. S. **3**:582–584. *figs. 1–4.* 1896.

excavations in the Cretaceous clays at Kreischerville, particularly that known as the Androvette pit, where the largest quantities of amber have been found. We were fortunate enough on this occasion to secure a large quantity of lignites, including several fragments of some size, showing the amber *in situ*. On a subsequent visit, in the following autumn a further supply of material was secured, including some admirably preserved Pityoxylon from a newly opened excavation known as the Drummond pit.

The lignites gathered at Kreischerville belong to at least three genera: Araucarioxylon, Cupressinoxylon, and Pityoxylon. Of these only the last proved to be succiniferous. The first two genera mentioned represent several species and present features of very considerable interest, but it is not our intention to discuss them further here. The pityoxyloid lignite containing masses of amber was found in the form of large pieces from the various excavations at Kreischerville, as well as in smaller fragments occurring in the amber-bearing strata themselves, at the Androvette pit, as described by Dr. HOLLICK (*l. c.*). The amber enclosed in lignite appears both in the translucent shining condition and in the dull ochraceous modification. In the latter state it is particularly conspicuous on account of the contrast in color with the black lignite, and may be made out not only in the form of pockets and nuggets, but also as fine yellow threads or streaks corresponding to the normal resin passages of the wood. Unfortunately the state of preservation of most of the succiniferous lignites left something to be desired. In the Drummond and Androvette pits, however, were found a number of partially charred, and, as a consequence, exquisitely preserved Pityoxyla, which were apparently specifically identical with or at any rate closely allied to the actually succiniferous fragments of Pityoxylon. It has been thought advisable to defer the description of the amber-containing lignites until a greater quantity of material should be accumulated, which might not only be better preserved, but might also throw some light on the conditions leading to the formation of amber. The partially charred lignites belonging to the genus *Pityoxylon* Kraus appear, nevertheless, worthy of immediate investigation, both because they show features of considerable phylogenetic interest, and because the genus Pity-

oxylon is considered by some paleobotanists not to antedate the Tertiary.[4]

The specimens of Pityoxylon, which have served as the material for the present investigation, consist for the most part of cylindrical fragments, which are sometimes as thick as 10^{cm} and often twice as long. Most of them however are of smaller size. Where the pieces are cylindrical they generally include the pith in a good state of preservation, a feature of some importance in connection with their diagnosis. It is not possible to state absolutely from the nature of the specimens whether they represent smaller branches or merely the core of larger axes from which the external layers have been burned off. From the ordinarily tylosed condition of the resin canals, it may be inferred with a strong degree of probability that the latter supposition is more likely to be correct. Angular fragments showing annual rings with a large radius of curvature permit a study of the structure of the older wood. Although at least two different species of fascicles of pine needles and at least as many species of cone scales of Pinus, all in an admirable condition of preservation, have been found in association with the Pityoxyla from the Androvette pit, it has not been possible to distinguish in these lignites more than one type of wood structure. The material in this respect presents an interesting parallel to the condition found by CONWENTZ[5] to exist in the Pityoxyla of the Eocene or early Oligocene, which bear the well-known Baltic amber; for this author declares that he is unable in the vast variety of fossil succiniferous woods which have passed under his inspection to diagnose more than a single species. The absence of clearly marked criteria for the separation of species on the basis of wood structure is not surprising, since even in the case of living pines it is difficult to do more than segregate the various species into larger groups or sections on the characters offered by the wood.

Fig. 1 shows the structural features of a transverse section of a slightly flattened branch about 5^{cm} in thickness in its greatest diameter, and showing more or less distinctly about twenty annual

[4] *Cf.* GOTHAN, Zur Anatomie lebender u. fossiler Gymnospermen-Hölzer 88. Herausgeb. von der Königlich Preussischen Geologischen Landesanstalt und Bergakademie. pp. 108. Berlin, 1905.

[5] Monographie der Baltischen Bernsteinbäume. Danzig, 1890.

rings. It is to be observed from the photograph that the annual rings are not as strongly marked as they are in pines of the present day. This feature is due to the less pronounced thickening of the tracheids of the summer wood. There are no parenchyma cells present in the wood except those which surround the resin canals. The rays are strongly marked on account of the resinous character of their contents, a feature of difference from modern pines, where as a rule the ray-cells are quite free from the dark brown secretion which is characteristic of the resiniferous cells in the Cupressineae and in the genera Cedrus and Tsuga among the Abietineae. The resin canals show a tendency to become aggregated in clusters. They may be almost absent in one or more annual rings and correspondingly abundant in others. The resin ducts are surrounded by highly resiniferous cells and appear not to be confined to any special region of the annual ring. On the left of the figure is to be seen a resin canal occluded by tyloses.

Fig. 2 shows a section of the same branch which includes a portion of the pith. The medullary cells are filled with dark brown contents. Sclerified cells are quite absent in the pith. To the right of the photograph a process passes off from the medulla, which is the pith of a small branch, in all probability a brachyblast or short shoot. In the wood immediately adjoining the pith may be seen a number of resin canals, closely filled with tyloses. The position of these resin canals in relation to the pith is that found among living species of Pinus, in the hard pines (*Scleropitys* auct.), in which the resin canals also abut on the pith, in some cases actually occurring in the primary wood, in contrast to the soft pines (*Malacopitys* auct.), where the resin ducts are somewhat remote from the pith and never occur in the primary wood. The annual rings are generally less well marked in proximity to the medulla than in the more external part of the wood.

Fig. 3 is a longitudinal radial view of the wood of the same specimen illustrated in the two preceding photographs. The section shows a single vertical and several anastomosing horizontal resin canals, all quite filled with tyloses. A careful inspection indicates that the wood is made up of tracheids, which are provided with a single vertical row of radial bordered pits.

Fig. 4 shows the structure of the wood in the same specimen, as seen in tangential section under a low magnification. The rays are of the two kinds found in *Pityoxylon* Kraus, namely, linear and fusiform.

Fig. 5 shows a tangential view of part of the same section, more highly magnified. In this view the radial pits of the tracheids may be seen in profile, and on the left a face view of a few tangential pits. In some of the rays dark contents may be made out in the cells, which have partially shrunk away from walls. This is apparently of the same nature as the dark brown material found in the resin cells of certain living conifers. The interesting fact to be noted is that the resin occurs equally in the marginal and in the central cells of the ray. This feature may be clearly distinguished in two of the rays on the lower left portion of the photograph. In living pines resin never occurs in the marginal cells of the ray, which, as is well known, are not true parenchymatous cells, but are of a tracheary nature. They are in fact variously described as marginal tracheids, horizontal tracheids, and tracheidal cells.

Fig. 6 shows another portion of the same section as that represented in *fig. 4*, on the same scale of magnification as *fig. 5*. This figure shows very clearly the occurrence of tangential pits, which are confined to the autumnal tracheids as in certain living species of Pinus. In *figs. 5* and *6* may be seen fusiform rays containing horizontal resin canals occluded by tyloses.

Fig. 7 represents a transverse section, under high power of magnification, of the autumnal wood of a specimen showing annual rings with a large radius of curvature. The elements are much larger in this instance, as is the rule in the older wood of the Coniferales in general. The tangential pits of the autumnal wood can be very clearly made out. We have found no specimen of Pityoxylon from the Kreischerville deposits in which the tangential pitting of the autumnal tracheids is not a marked feature. CONWENTZ has pointed out that this feature is also present in the autumnal wood of the Baltic amber-producing trees (*l. c.*, p. 21).

It will be inferred from the above description that the Cretaceous Pityoxyla just described differ in several features from the woods of any modern or even Tertiary species of Pinus. The leafy short-

shoots found in intimate association with the Pityoxylon here described, which unquestionably belong to the genus Pinus in the narrower sense, have the double bundle which is characteristic of the hard pines,[6] as has been learned by one of us from a microscopic investigation of their structure. They are also provided with the persistent foliar sheaths, which are a striking feature of the hard or pitch pines in contrast to the soft pines, which have deciduous sheaths. All the numerous cone scales found in intimate association with the wood, illustrated in our *figs. 1–7*, are equally characteristic of the hard pines, for they have the thickened apophysis and median umbo, which are unfailing features of that group. In the case of our Pityoxylon, however, we find universally present the tangential pits of the autumnal tracheids, which are characteristic of the existing soft pines.[7] STRASBURGER, however, states that he has found tangential pits to be present in the autumnal wood of *Pinus canariensis* and *Pinus rigida*. MAYR[8] has also called attention to the occasional occurrence of tangential pits in the autumnal wood of one group of the hard pines. This feature has also not escaped the notice of CONWENTZ. One of us has observed the very frequent occurrence of tangential pits in the autumnal wood of the *cone* in various species of hard pines, where they are quite absent in the vegetative wood. This is the case, for example, in the woody axis of the cone of *P. Pinaster*, the vegetative wood of which is described by KRAUS[9] as having no tangential pits. *P. palustris* too, although it is a characteristic hard pine, in the absence of tangential pits from its autumnal wood,[10] possesses these in great abundance in the autumnal wood of its cone, in both the annual rings present. These two examples will suffice to illustrate the fact that tangential autumnal pits, such as are ordinarily absent in the wood of hard pines, are generally present in their *cones*. It may be inferred from the mode of their occurrence that tangential

[6] COULTER and ROSE, Synopsis of North American pines based on leaf-anatomy. BOT. GAZETTE 11:256, 302. 1886.

[7] PENHALLOW, Anatomy of the Coniferales. Amer. Nat. 38:243. 1904. STRASBURGER, Ueber den Bau und die Verrichtungen der Leitungsbahnen in den Pflanzen.

[8] Waldungen Nordamerikas.

[9] Beiträge zur Kenntniss fossiler Hölzer, p. 25.

[10] PENHALLOW, *loc. cit.*, :04.

bordered pits in the tracheids of the hard pines are an ancestral feature. It is accordingly not surprising to find them more commonly present in older types of hard pines than those now living. CONWENTZ in his admirably accurate and thorough account of the wood of *Pinus succinifera* notes their invariable presence in this species, which on account of its denticulate marginal ray-tracheids must be considered to belong to the hard pines. As has already been pointed out, the structure of the associated leaf fascicles and cone scales leads to the conclusion that the Cretaceous Pityoxylon under discussion belongs also to a hard pine. The mode of occurrence of the resin canals in the medullary crown, which is illustrated in *fig. 2*, is also that which is characteristic of the hard pines.

The most reliable feature of difference separating histologically the hard pines from the soft pines is the occurrence of denticulate marginal tracheids in the former group. In the soft pines the marginal tracheids are entirely without denticulations. In our Pityoxylon, as has been shown above, marginal tracheids of any kind are quite absent; so that it is not possible on this feature to diagnose the affinity of our material with either of the two main groups of pines still living. It is of interest to note that the Cretaceous Pityoxylon under discussion has the general structure of the rays found in Abies or Pseudolarix, with the wood structure found in Tertiary and modern species of Pinus. There can be little doubt that in the peculiar structure of the rays we have to do with an ancestral feature; for if we take for example a modern species of Pinus, in which the marginal tracheids are well developed even in the first annual ring, such as *P. palustris*, we find the marginal tracheary cells entirely absent in most of the rays of the two annual rings of the female cone. It is well known that in many of the modern species of Pinus the marginal tracheary ray-cells do not appear until the branch is from one to several years old. The same feature, if one may judge from CONWENTZ' description, was also present to an even more marked degree in the Baltic amber pines, which are considered by CONWENTZ to belong to the early Oligocene or late Eocene. Another feature of striking resemblance presented by the wood of the *cones* only of existing species of Pinus, to the vegetative woods of Cretaceous Pityoxyla which we have investigated, is the highly

resinous character of the ray-cells. This feature may also be well seen in *P. palustris*, already referred to. The contrast in the contents of the ray-cells as they occur in the wood of the cone or of a vegetative branch is very strongly marked.

It may be inferred that we have overlooked the presence of tracheary marginal cells in the Cretaceous Pityoxyla, which are the subject of the present article. This view cannot however be accepted, as the wood of some of our partially charred specimens is in a perfect condition of preservation, often not even showing the spiral striations which are generally found as a feature of decay in many fossil woods, otherwise well preserved. Moreover, in shallow rays consisting of a single stratum of cells, which in the case of modern species of Pinus are composed entirely of tracheids, the cells are parenchymatous and invariably filled with a dark brown resinous content, which leaves no doubt as to their histological nature. The cells on the margins of the rays in our Pityoxylon are moreover related to the central cells of the rays and to each other by simple pits and not by bordered pits, as is the case with the marginal tracheids. It is obvious that the ray-structure of Pinus underwent a great change in the passage from the Mesozoic to the Tertiary period.

On account of the geographical occurrence of the Pityoxylon, which has just been described, it is called **Pityoxylon statenense.** The diagnosis is as follows:

Transverse.—Annual rings narrow, sometimes not clearly marked; wood parenchyma absent except in the periphery of the resin canals, which may occur in any part of the annual rings and are often stopped with tyloses; rays highly resinous; bordered pits present on the tangential walls of the autumnal tracheids; tracheids about 25 μ in diameter.

Radial.—Radial pits of tracheids about 17 μ in diameter, in a single vertical row, round with a round mouth; pits of the ray-cells about one per tracheid, round or somewhat elliptical, 10 μ in diameter; ray-cells all parenchymatous, very resinous, length from 100 to 120 μ; marginal ray tracheids quite absent.

Tangential.—Rays of two kinds, linear and fusiform, the latter containing resin canals which are surrounded with rather thick-walled parenchyma; resin canals often occluded by tyloses; tangential pits present in the autumn wood.

In addition to the Pityoxylon described above, we have examined another of the same type, which was secured by Dr. ISAAC BOWMAN

from a newly exposed section at Third Cliff, Scituate, Mass. Although there is some question as to the exact geological age of the strata from which it was taken, it is considered desirable to refer to it at the present time on account of the interesting similarity to the species discussed above. DR. BOWMAN describes[11] the section from which the material was taken as follows: "The section at Third Cliff shows yellow clays at the base conformably overlain by yellow and white sands and succeeded by a bed of bright red sands with an unconformity at their base. On the eroded edges of the red and white beds are deposited dark glauconitic and lignitic clays and sands. The entire series of beds has a total maximum thickness of 60 or 70 feet and outcrops for half a mile along the cliff face. Absolutely no erratic material occurs either within the beds themselves or along the lines of unconformity." The lignite to be described came from the "lignitic sands and clays" just mentioned.

The material consisted originally of several laminated and badly preserved fragments, together with one larger piece, cubical and about 12^{cm} in its three dimensions. The better-preserved fragment has served as the basis of the following description. As the result of decay and pressure, the lignite has suffered some compression both in the radial and tangential planes. The stress in the radial plane has produced a considerable sinuosity in the course of the wood rays. The annual rings cannot be made out with the naked eye or even with a pocket lens of some degree of magnification.

Fig. 8 shows a magnified portion of a transverse section of this wood. The area of the photograph includes parts of two annual rings. The line of demarcation is very indistinct and runs obliquely a little above the lower third of the photograph. The rays are very dark on account of the highly resinous character of their contents. Two large patches of parenchyma may be seen surrounding two vertical resin canals. The large amount of resiniferous parenchyma about the canals is particularly characteristic of this species. There are no parenchyma cells in the wood other than those surrounding the resin canals. The annual rings have a very slight radius of curvature and are somewhat distorted on account of the compression of the wood, although the elements which compose them are well

[11] Science N. S. 22:993–994. 1905.

preserved. The lignite under discussion obviously is part of an old stem.

Fig. 9 is a radial view of the wood of the Pityoxylon from the cliffs at Scituate. This view shows the extremely resinous character of the rays, which doubtless is largely responsible for the good preservation of the wood, as, unlike the material of *Pityoxylon statenense*, it has not been charred in any way by fire. The rays are quite without tracheidal marginal cells and in this respect resemble those of the first described species, and differ from the ray vegetative structure found in any modern species of Pinus.

Fig. 10 shows a tangential view of the wood. The rays are obviously of two kinds, namely, linear and fusiform. The former are often very deep, and in this feature present a marked contrast to the first described species of Pityoxylon. The fusiform rays are usually occupied by a horizontal resin canal, the lumen of which is often filled with a dark brown material similar to that found in the surrounding resiniferous cells of the ray. Tyloses have not been found either in the horizontal or the vertical resin canals of this species.

Fig. 11 shows a portion of the same section more highly magnified. The highly resinous character of the rays can clearly be made out. There is one fusiform ray present containing a horizontal resin canal, which is filled with a dark brown material similar to that found in the ray-cells. It may here be stated that in spite of the fact that the cells surrounding the lumina of the horizontal and vertical resin ducts cannot be described accurately as being thick-walled, nevertheless the ducts are never occupied by tyloses.

Fig. 12 shows another tangential view under considerable magnification. This illustrates the fact that in the rays the marginal as well as the central cells contain the same dark brown resin, as has already been referred to in the case of the other Cretaceous Pityoxylon described above. The wood is so well preserved that there can be no question as to the absence of marginal tracheids, such as occur in the rays of living species of Pinus and allied genera. Not only are the marginal cells filled with the same dark resinous material as the other cells of the ray, but they are related radially to each other, as well as to the central cells of the ray, above and below by simple pits.

This species of Pityoxylon is named **Pityoxylon scituatense,** from its place of origin. The diagnosis is as follows:

Transverse.—Annual rings moderately broad, indistinctly marked; resin ducts present, surrounded by a very deep zone of resiniferous parenchyma, without tyloses but sometimes filled with dark resinous contents; wood parenchyma quite absent; rays very dark and resinous; tracheids averaging 39 μ in diameter.

Radial.—Radial pits of the tracheids in a single row with the very oblique narrow mouths forming a cross, diameter of the pits about 20 μ; pits of the ray-cells generally one per tracheid with narrow oblique mouth, about 10 μ in diameter; ray-cells all parenchymatous, average length 340 μ, very resinous; marginal ray-tracheids quite absent.

Tangential.—Rays of two kinds, linear and fusiform, the former often very deep; fusiform rays containing horizontal resin canals, which are always free from tyloses although somewhat thin-walled, both kinds of rays very resinous; tangential pits present in some of the tracheids.

In the two species of Pityoxylon described above, we have to do with woods which resemble those of the existing pines, but which nevertheless differ from them in important particulars. The marginal ray tracheids, which are not only characteristic of Pinus but of the allied genera Picea, Pseudotsuga, and Larix, are quite absent in our two species. The question arises whether it is proper to include them within the genus Pityoxylon, which has recently been stated not to antedate the Tertiary.[12] There is much to be said for such a course. In the case of our *Pityoxylon statenense* there can be no reasonable doubt that we have to do with the wood of a fossil species of Pinus, from the abundant occurrence in intimate association with the lignites of charred remains of cone scales and leaf fascicles of pines. Any doubt as to the identity of these scales and foliar shoots has been removed by a study of their microscopic structure, as well as their external features. Further, one of us has observed from the study of the *cones* of living pines that the features which are characteristic of our fossil woods are exactly those which are found to be distinctive of the wood structure of the cones of the living species of Pinus. There can be little doubt that in the case of the wood of the cones of *Pinus palustris*, for example, the general absence of marginal tracheids, the highly resinous character of the rays, and the abundant presence of tan-

[12] GOTHAN, *l. c.*, p. 88.

gential autumnal pits, all features of difference from the vegetative wood structure of existing hard pines, are ancestral characters, since such characters are wont to linger on in the reproductive axis. Indeed in no other way can the presence of these features in the wood of the cone be explained. It seems inadvisable to invent a new generic name for a fossil wood, which although lacking the marginal ray tracheids, which are characteristic not only of the wood of living pines, but of also Pityoxylon as generally defined, is beyond any reasonable doubt the wood of a Cretaceous pine. We find it difficult to follow GOTHAN (*l. c.*, p. 102) in establishing a new pityoxyloid genus of fossil woods, Pinuxylon, to which is assigned the ligneous characters of the living Pinus in the narrower sense. *Pityoxylon* Kraus seems rather in need of a wider than a narrower interpretation, if it is to include the wood of Pinus of the Cretaceous as well as Tertiary times. In the case of our *Pityoxylon statenense* there can be no reasonable doubt that we have to do with the wood of an extinct Cretaceous pine. It seems on account of its distinctive archaic features, however, inadvisable to name it under Pinus as CONWENTZ has rightly done in the case of the Tertiary *Pinus succinifera*, which is practically identical in its wood structure with modern hard pines. The retention of the genus *Pityoxylon* Kraus appears, for the present at any rate, absolutely essential in view of such cases as that presented by our *Pityoxylon statenense.* The evidence as to *Pityoxylon scituatense* is much less clear, as no cone scales or leaves have been found with it. Since, however, it presents the same general features as *P. statenense*, it may conveniently be included under the same genus.

There is good reason to believe from recent researches[13] that the genus Pinus in essentially its modern form, so far as the external features of the female cones go, existed as far back as the Jurassic. There is even evidence that the two great series of the hard and soft pines existed at this early period so that the geological extension of the genus must have been much more remote. Without considering the evidence for the existence of Abietineae at earlier geological periods than the Tertiary, furnished by impressions of the

[13] FLICHE, P. et ZEILLER, R., Florule portlandienne des environs de Boulogne-sur-Mer. Bull. Soc. Géol. France IV. 4:787–812. 1904.

foliage, etc., there are now definite records, based on internal structure, which carry the group far into the past. KNOWLTON[14] has recently described an abietineous wood from the Jurassic beds of the Black Hills of Dakota which he calls *Pinoxylon dacotense.* It is characterized by the possession of vertical resin canals only, which are numerous and may occur in any part of the clearly marked annual rings. The structure of the tracheids and rays is that of the Abietineae. This author does not mention the presence of marginal ray tracheids, and in view of the fact that he describes the wood as admirably preserved, they probably may be considered to be absent here as in our Cretaceous Pityoxyla.

The *Pityoxylon Conwentzianum* of GOEPPERT from the Carboniferous of Waldenburg,[15] which has often been called in question, has received full confirmation from the description of a similar type of Pityoxylon, *P. chasense*, by PENHALLOW[16] from the Permian of Kansas. In these two species vertical resin canals are said to be absent, although the horizontal canals of the fusiform rays are clearly present. There is, accordingly, every reason to believe that the Abietineae are a very ancient group in their first appearance. In fact, they may be traced geologically quite as far back as the Araucarineae, which it is customary at the present time to regard as the oldest of the Coniferales. That they are not more numerously represented in the Mesozoic and earlier strata is probably entirely a matter of antisepsis, since araucarineous remains are in general much better preserved than are those of the Abietineae, where they are found imbedded together in the same strata. Mention need not be made here of the *Pityoxylon eggense* (Witham) Kraus and *Pityoxylon Hollicki* Knowlton,[17] since both of these appear to have been in a bad state of preservation.

The peculiar structure of the wood of Pinus in the Cretaceous, as distinguished from that found in the case of Tertiary and living pines, probably affords an explanation of the greater vigor of the

[14] U. S. Geol. Surv. Ann. Rept. **20**^{2}: 420–422. 1898–1899.

[15] GOEPPERT, Revision meiner Arbeiten.

[16] North American species of Dadoxylon. Trans. Roy. Soc. Canada II. **6**^{4}:76. 1900.

[17] Trans. N. Y. Acad. Sci. **16**:134–136.

genus under modern conditions. It is generally inferred that genera which flourish under modern conditions cannot be of very ancient origin. This generalization, however, cannot be accepted in the case of Pinus, which, although found actually abundantly throughout the northern hemisphere in from 80 to 90 species, can be traced in obviously allied genera back to the Carboniferous. The appearance of marginal ray tracheids about the beginning of the Tertiary epoch, with the resulting improvement of water-supply, in all probability explains why so comparatively large-leaved a conifer should have been able not only to live on into the modern period, but to flourish as it never had before. Even at the comparatively early epoch of the Baltic amber beds (probably Eocene), there were numerous species present in the somewhat restricted area represented by that formation.

CONCLUSIONS.

1. The woods of certain pines of the Middle Cretaceous of Staten Island differed from those of existing pines (*a*) in the absence of marginal tracheids in the rays; (*b*) in the highly resinous nature of the rays; (*c*) in the association of characteristic features of the hard pines, as exemplified by leaf-fascicles, cone-scales, and structure of the primary wood, with the numerous tangential pits of the autumnal wood which are a feature of the living soft pines.

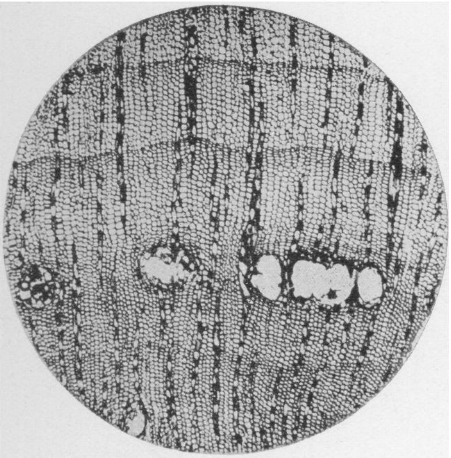
2. These features of difference from modern pines are probably to be regarded as ancestral, since they persist clearly and strongly in the structure of the wood of the cones of the living species.

3. The appearance of marginal tracheids in the rays of Pinus is comparatively modern and does not in all probability antedate the Tertiary. It probably explains the greater prosperity of the genus in recent times.

4. Another species of Pityoxylon from Scituate, Mass., has been described, which has the general features of the Pityoxyla of Staten Island. It is not possible, however, to refer it definitely to Pinus, nor is its geological horizon settled.

In conclusion we wish to offer our warm thanks to Dr. Hollick for many kindnesses in the matter of securing material.

Harvard University.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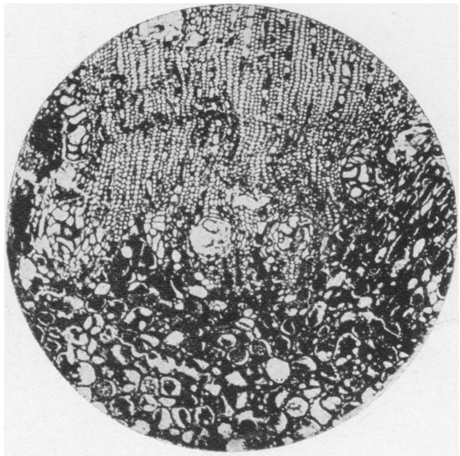
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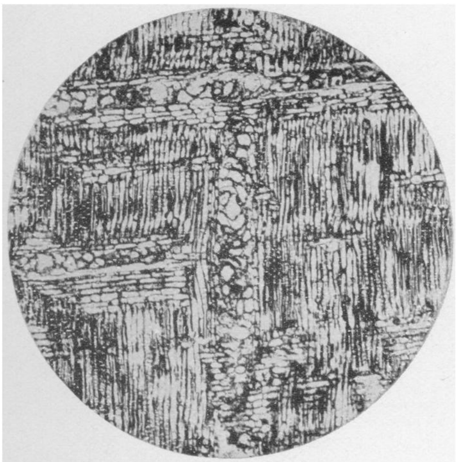
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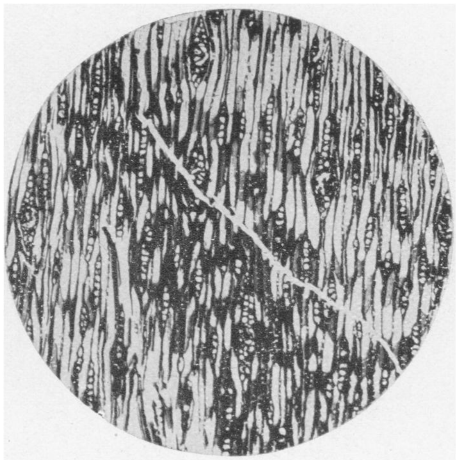
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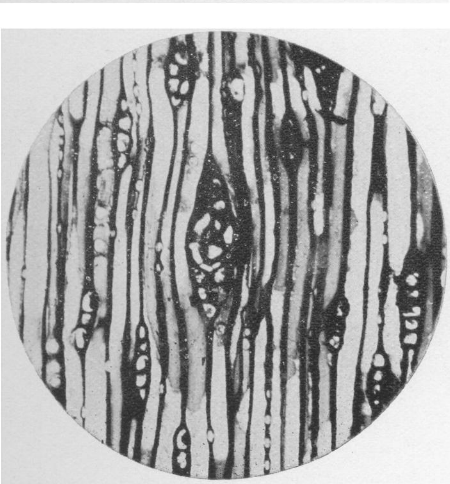
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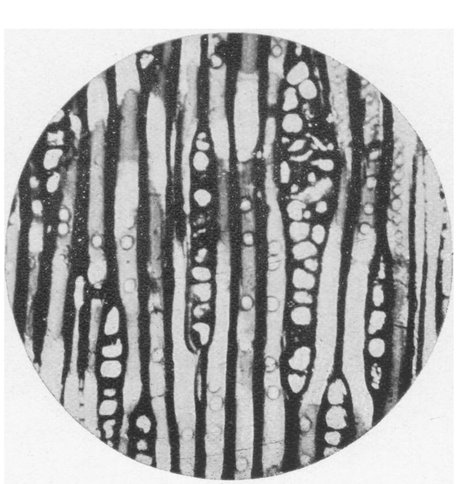
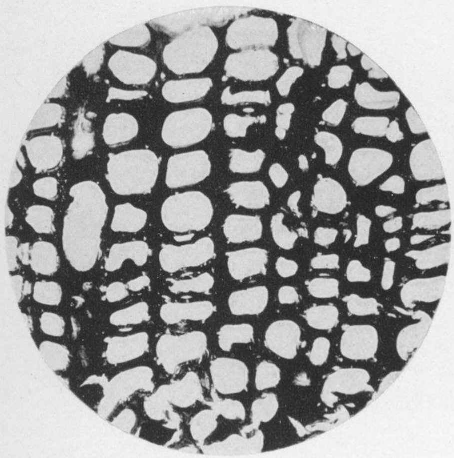

6

JEFFREY & CHRYSLER on PITYOXYLA



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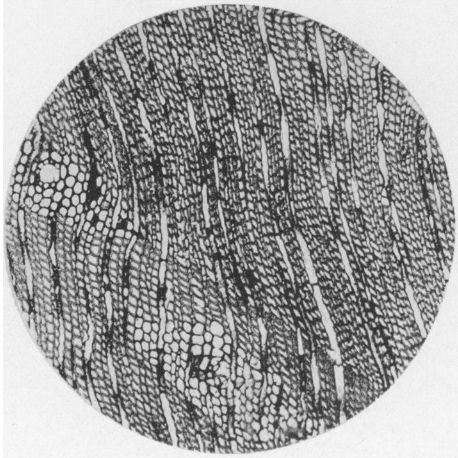

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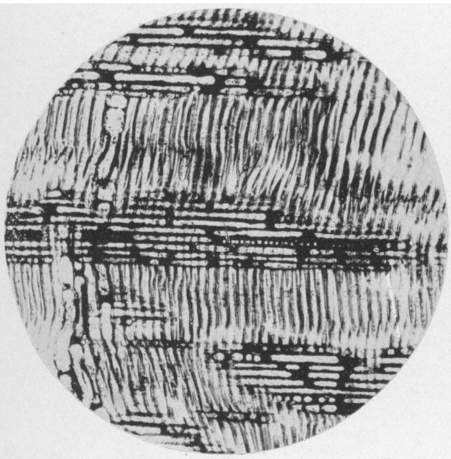

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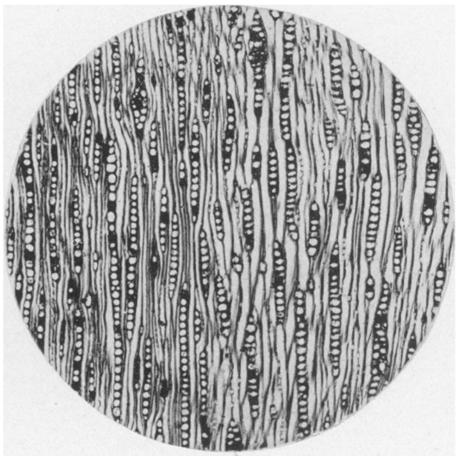

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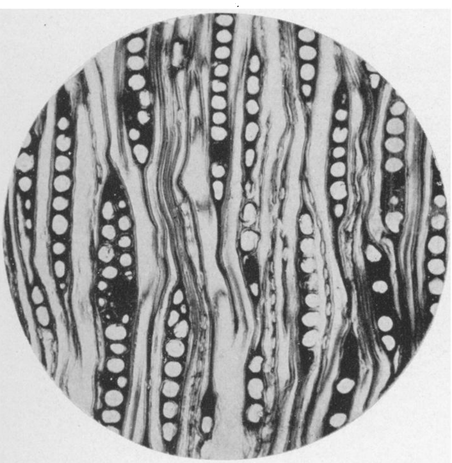

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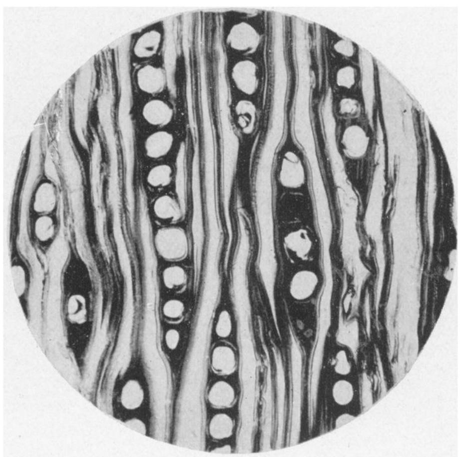

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JEFFREY & CHRYSLER on PITYOXYLA

EXPLANATION OF PLATES I AND II.

PLATE I.

Pityoxylon statenense.

FIG. 1. Transverse section of the wood. ×20.
FIG. 2. Transverse section of the wood near the pith. ×40.
FIG. 3. Radial section. ×60.
FIG. 4. Tangential section. ×60.
FIG. 5. Tangential section. ×180.
FIG. 6. Tangential section. ×180.

PLATE II.

FIG. 7. Transverse section. ×200.

Pityoxylon scituatense.

FIG. 8. Transverse section. ×60.
FIG. 9. Radial section. ×30.
FIG. 10. Tangential section. ×60.
FIG. 11. Tangential section. ×180.
FIG. 12. Tangential section. ×180.